CHITINOZOA FROM THE ORDOVICIAN
POINT PLEASANT AND KOPE FORMATIONS
OF SOUTHWESTERN OHIO

Approved:
[illegible]

A Senior Thesis
submitted by:
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INTRODUCTION

Chitinozoa were discovered by Alfred Eisenack in 1929 in insoluble residues of glacial erratics of Ordovician and Silurian age. These erratics originate from Sweden and the North-eastern Baltic, and were deposited in Northern Germany and adjacent areas. Eisenack developed the first taxonomy of the group, and he described six genera and twenty-six species in his original paper. Eisenack has continued to be one of the foremost experts in the study of the Chitinozoa, and he has been active in research on the group up to the present.

The first report of Chitinozoa in North America was by Stauffer in 1933, when he reported specimens from the Decorah Formation of Minnesota.

In 1942, Deflandre reported the presence of the group in France, confirming their presence in Lower Paleozoic strata in Western Europe.

Since that time, the study of the group has expanded greatly (though most of the work has been fairly recent). Chitinozoans have subsequently been reported in Africa by Taugordeau (1962), and economic geologists have discovered Chitinozoa in all areas of Lower Paleozoic rocks in the world. Important recent workers in the field include C. Collinson, L.R. Wilson, F.W. Lange, S. Laufeld, W.A.M. Jenkins, J. Jansonius, F. Cramer, and J.B. Urban.

Jenkins and Urban have been the most active workers in this country in recent years. Jenkins has described numerous samples from the Ordovician of the Arbuckle Mtns. of Oklahoma, as well as from Shropshire in Britain. He has distinguished range zones of the species in each section, and evaluated the stratigraphic significance of these zones. Urban has been active in the study of Chitinozoa from the Devonian Cedar Valley Formation of Iowa. Laufeld published a paper on Ordovician Chitinozoa in 1967, and his recently published paper on the Silurian Chitinozoa of Gotland is outstanding. Both he and Urban have employed to a great extent what I feel is the most important tool to the micropaleontologist- the Scanning Electron Microscope (SEM). Laufeld and Jenkins have carried out detailed biostratigraphic work, established stratigraphic ranges for individual species, and distinguished assemblage zones. Jenkins has also noticed evolutionary trends of some forms, notably Hercochitina crickmayi. Jansonius is working in Canada, and the majority of his work has been the revising of the taxonomy of the group. He has also attempted to describe the evolution of the Chitinozoan genera, some of which he has erected himself.

Much of the recent research on Chitinozoa has been devoted to the microstructure of the vesicle wall, a field in which Laufeld is the leader. Urban has also done much work on the wall of the vesicle, and also on other structures as well. Jenkins has done some research on the spines, operculum, and the aboral pits of some forms (Cyathochitina kuckersiana, etc.). He has also presented evidence of possible parasitic activity on their vesicles. Jenkins, however, has used light microscopy, which does not give the resolution or the detail necessary to identify separate species or structures, especially when they are preserved compressed. In recent work, the SEM has been used with considerable success for the study of these fossils

Laufeld (1974).

Interest in the chemical composition of the Chitinozoan vesicle followed soon after their discovery. The name is a misnomer, really; their vesicles are composed of a pseudochitinous material, not a chitinous one as the name implies.(chitin is a polymer of acetylglucosamine. It consists of long chains of the nitrogen-containing sugar, glucosamine). In order to find out the chemical composition of Chitinozoans, Eisenack (1931) conducted experiments similar to those of Jepps (1926). He subjected the vesicles to concentrated acid and base solutions, with the vesicle coming out unscathed. Jepps had performed her experiment on the thecamoeban Gromia oviformis, which has a pseudochitinous test. Results showed that the test was insoluble. Chitin, when subjected to the same procedure, is affected by caustic soda if the chitin has already been hydrolized by heating with a concentrated acid. Eisenack concluded that Chitinozoan vesicles are not composed of chitin, but the composition is more stabilized by being anhydrous.

Kesling (1951) took an X-ray powder photograph of a dried Daphnia longispina - the water flea- whose test is entirely chitin. It indicated an almost amorphous structure. W.F. Bradley performed the same experiment (Collinson and Schwalb, 1955) using pieces of Angochitina flasca and achieved the same results, but, due to the haloes being too diffuse, no real conclusions could be drawn.

Collinson and Schwalb (1955) believe that the composition of the Chitinozoan wall may have been changed somewhat during preservation, and that it is close enough to the original composition to be called pseudochitinous.

MORPHOLOGY

Chitinozoa are of various shapes and sizes; they range from flask-shaped to conical, and from bell-shaped to cylindrical forms. Their length may be as small as 60 microns, or as large as 2000 microns.

The wall is very dark and opaque (it may be amber and translucent) and usually of two or three separate layers. These layers are called the periderre, ectoderre, and the endoderre (Combaz, et.al.,1967). The periderre is the most exterior layer, and is delicate and spongy and easily removed. It is therefore the least observed of the layers. Ornamentation developes in the periderre. The ectoderre is the middle layer, but is the most frequently seen layer when we look at the vesicle. The endoderre is the inner layer. The internal structures (prosome, opisthosome, etc.) are formed from this layer.

The prosome is a cylindrical, opaque structure contained within the neck of the vesicle. Jansonius (1964) believes it is contractile and retractile within the neck, but Urban (1972) disagrees. He feels it may be a solid, reproductive organ, which forms egg-cysts, and these peel off as the animal matures. The opisthosome is a very rarely seen structure (Combaz, et. al., 1967, Urban,1972). Its placement is on the inside, on the aboral end of the vesicle. It is conical, narrowing oralward. Urban (1972) suggests that it may have a reproductive function.

The operculum is a thin membrane of unknown function, which is either contained inside the neck, or is external.

Jansonius (1964) writes of ornamentation which consists of "hollow spines, horns, or a skirt-like flange," and he believes the vesicle is an exoskeleton of the animal that secreted it. Laufeld (1974) however, has proven (with the SEM) that the hollow spines do not reach the inside of the vesicle, but were secreted by some tissue external to the wall. In either case, ornamentation may consist of simple spines, or lambda and pi spines (in any combination), and tiny projections on the vesicle wall.(granules).

Collinson and Schwalb (1955) illustrate a collar which was attached to the inside of the neck, and extended outward, perhaps with flagellae, as in the Choanoflagellates. I have seen nothing like this in my specimens; perhaps these collars were preserved in cherts.

The base of the vesicle is very different in different forms; some show a puckered lip, or mucro, as in C. minnesotensis, while others may show a basal callus, with its associated basal scar. Others, like Cyathochitina kuckersiana, have a narrow flange or skirt on their basal edge.

There seems to be general agreement that Chitinozoans are the remains of animals, even if there is disagreement as to which group they belong. Therefore, the International Rules on Zoological Nomenclature are followed here. As an example of the controversy, C.L.Cooper (1942) has associated the group with the Hydrozoa, or certain (unnamed) Mid-Paleozoic chitinous foraminifera, while Collinson and Schwalb (1955) believe that the group are protozoans, either Rhizopods or Choanoflagellates. Jenkins (1970) has associated the Chitinozoa with the graptolites, a group with which they are closely associated stratigraphically. Kozlowski (1963) believes that the group may be non-planktonic eggs or egg-capsules of metazoans.

Classification is based upon the general shape of the vesicle, its ornamentation, flexure, size, and the position of its operculum. Most illustrations before 1970, however, were taken as silhouettes through the light microscope. I found these of little use in distinguishing forms, indeed impossible to use,in some cases.

The stratigraphic range of the Chitinozoa is Lower Ordovician to Lower Carboniferous. The group evelved rapidly during the Ordovician, and continued through the Lower Devonian, where it started its decline. In the beginning, large poorly ornamented forms evolved, but by the Upper Silurian, the vesicles were smaller, and more delicately or heavily ornamented.

PALEOBIOLOGY

Due to the fact that their vesicle is the only preserved structure of these animals, the biology of the group is necessarily vague, and can only be inferred. Some forms (Angochitina bifurcata, etc.) have an aboral pit, which may have served as a receptacle for a holdfast organelle. This infers a benthonic mode of life. Others (Conochitina robusta,etc.) have spines, which may have added buoyancy, or allowed it to attach itself to floating organisms or debris, which suggests a pelagic mode of life. The collars of some Chitinozoa probably served the same function as in the Choanoflagellates, i.e. as a food gathering device.

PALEOECOLOGY

Chitinozoa have been found in abundance in all marine rocks of Lower-Middle Paleozoic age, except for reef limestones (Laufeld,1967). The latter may be due to the high energy in these environments. The fact that the delicate spines and other ornaments are generally so well preserved suggests that the environments in which Chitinozoans lived was one of low energy, and that these fossils might make up a life assemblage. Their distribution in most marine rocks, including dolomites and cherts, suggests that they were probably pelagic organisms.

PURPOSE OF THE INVESTIGATION

Chitinozoa have never been extensively investigated in the Ordovician of the Cincinnati area. The only reference on such work is in an abstract by J.M. Schopf and T.J.M. Schopf (1961), in which they discussed mainly the preparation of these microfossils on slides.

I wanted to explore the occurence of Chitinozoa in the Cincinnati area, their abundances and faunal variations, and see if I could discover any biostratigraphic potential for the group especially in the case of the base of the Cincinnatian - the North American Standard for the Upper Ordovician, in its type area.

The Bear Creek Quarry section was chosen because it is a very critical interval- the lower part of the section is the topmost Champlainian (the North American Standard Series for the Middle Ordovician), and in the middle of the section it becomes the basal Cincinnatian. It is always important to have the base of a Series well covered by useful fossils, and it was thought that Chitinozoa could help identify the Cincinnatian here, and then perhaps elsewhere.

PROCEDURES

Samples were obtained from the 60BCK (Bear Creek Quarry) section run for conodonts by S.M. Bergström and W.C. Sweet. (see Appendix)

I selected fifteen samples from the section, generally at ten foot intervals, and including the base and top of the section.

Seventy-five grams of each sample was processed in a 25% solution of Hydrochloric acid for 5-24 hours to dissolve the carbonates, then in a 25% solution of Hydrofluoric acid for 3-24 hours.

I used a 200 mesh sieve (with 74 micron openings) to rinse the residue, being careful not to agitate the fossils too much. The residue was then washed into Petri dishes, and the material preserved in water until it could be examined. Chitinozoans were picked out of the residue using a micropipet capped by a rubber bulb, and stored in small glass vials. During the study, I used a Bausch and Lomb binocular light microscope with a 2X auxiliary lens, which gave me a range in magnification of 20X-140X.

Pictures of the vesicles were taken with the S4-10 Scanning Electron Microscope, using Polaroid film. Stubs for the SEM were prepared by attaching a piece of glass cover slip to the stub with silver paint. The Chitinozoans were placed, still wet, on the cover slip. After the water evaporated, the fossils were well attached to the cover slip. The cover slip was used so that a flat background could be had. The stub was then coated with a double coating of gold using a vacuum evaporator. Coating is necessary to protect the delicate vesicles, and to keep them from charging quickly when exposed to the strong electron beam.

EXAMINING THE RESIDUE

Chitinozoa were found in varying abundances in all samples of the section. They were generally well preserved, the exceptions being samples 60BCK-101.5 and 60BCK-111, the shales, in which the Chitinozoa were compressed and distorted. There was much other microfossil material in these samples, including scolecodonts (throughout the section), siliceous radiolaria and sponge spicules (particularly in sample 60BCK-11), as well as pieces of graptolites, brachiopod valves, coral, and complete pyrite-replaced gastropods.

The Chitinozoa were mostly very dark and opaque, but there were a few cases in which the wall was amber and translucent; in these specimens, the operculum was visible while in place.

The absolute abundance of Chitinozoa per sample varied tremendously. In the two shale samples, hundreds of specimens were recovered, while in some of the limestones, fewer than 20 Chitinozoans were found, and in one case, only three specimens were recovered from 175 grams of sample dissolved.

EVALUATION OF THE COLLECTION

Chitinozoa comprising 6 genera and seventeen species were found in the samples. These are:

Ancyrochitina multiradiata
cf *Ancyrochitina primitiva*
Conochitina cf *cactacea*
Conochitina fungiformis spinifera
Conochitina micracantha
Conochitina minnesotensis
Conochitina robusta
Conochitina tuberculata
Cyathochitina campanulaeformis
Cyathochitina kuckersiana
Desmochitina cf *minor*
Desmochitina minor elongata
Hercochitina crickmayi
Rhabdochitina gracilis
Rhabdochitina hedlundi
Rhabdochitina magna
Rhabdochitina usitata

Conspicuous is the absence of the *Desmochitina* forms. This diverse genus is barely represented here, while it is abundant in the sections of Jenkins (1967,1969) and Laufeld (1967). Perhaps this is due to the size of the sieve I used; the sieve may have allowed the 'escape' of the smaller forms, which range down to 60microns.

C. micracantha and *C. campanulaeformis* are by far the most abundant forms, sometimes comprising one-third to one-half of the specimens per sample. The rarer forms are in some cases represented by only one specimen, as in *A. multiradiata*, cf. *A. primitiva*, *C. cactacea*, *C. fungiformis spinifera*, and the *Desmochitina* species. The others are common in a few samples, and are very rare in the rest.

There is some correlation between the facies and the absolute abundance of Chitinozoa per sample. The two shale samples contain hundreds of specimens, much more than any of the limestones (the limestones of the Pt. Pleasant Fm. are generally more productive than those of the Kope Fm.). However, there does not seem to be any correlation between a facies and a certain species of Chitinozoan. No species is restricted by facies.

It is interesting to note that there seems to be a continuous sequence of forms as the Pt. Pleasant Fm. grades upward into the Kope Fm. There is no faunal break between samples 60BCK-70.5 and 60BCK-91.

Affinities of the fauna

The Bear Creek section has been dated by Bergström and Sweet (1966) on the basis of conodonts. The Pt. Pleasant Fm. is Upper Middle Ordovician, and the Kope Fm. is Lower Upper Ordovician. Bergström (1971) has correlated the Middle-Upper Ordovician of North America with the British Ordovician Series, and the Bear Creek section falls in the Middle of the Caradoc Series.

Jenkins (1969) describes 12 characteristic Ordovician forms, all of which were identified in the Viola and Fernvale Limestones of Oklahoma (M. Ord.), 11 of which comprise what he feels is the cosmopolitan element in this section.

The Cosmopolitan element of the Viola-Fernvale fauna	Ostseekalk of Gotland, N. Germany, Finland	Caradoc-Ashgill of Estonia	Caradoc of Dalarna, Sweden	Caradoc of Shropshire, England	The Bear Creek Section
Angochitina capillata	+	+			
Conochitina micracantha	+	+			+
Conochitina wesenbergensis	+	+			
Conochitina hirsuta			+	+	
Conochitina robusta	+	+	+		+
Conochitina minnesotensis	+	+	+		+

continued:

The cosmopolitan element of the Viola-Fernvale fauna	Ostseekalk of Gotland N.Germany Finland	Caradoc-Ashgill of Estonia	Caradoc of Dalarna, Sweden	Caradoc of Shropshire, England	The Bear Creek Section
Cyathochitina kuckersiana	+	+	+	+	+
Desmochitina minor	+	+	+	+	?
Desmochitina lata	+		+		
Rhabdochitina usitata				+	+
Rhabdochitina turgida	(in northern Europe, this species is known only from the Llanvirn-Llandeilo of Shropshire)				

-from Jenkins, 1969.

As you can see, I have recovered 6 species which are characteristic Ordovician Chitinozoa. Jenkins believes that there is a provincial fauna in the Viola-Fernvale sequence. Of the seven he has named, the only species which is common to mine is Hercochitina crickmayi, which seems to be restricted to No. America.

There are no forms which I have identified that are common to those reported by Jenkins (1970) from the Sylvan Shale, which overlies the Viola-Fernvale sequence, and is the Uppermost Ordovician in the Arbuckle Mtns. of Oklahoma.

RESULTS

The goal of the investigation was two-fold: to find whether Chitinozoa could be obtained and identified in the rocks of the section, and to examine whether they could be used biostratigraphically in that interval.

Chitinozoa were recovered in all the samples of the Bear Creek section. The frequency of specimens per gram of sample ranged from 0.02 grams per sample (in 60BCK-82) to 6.0 (in 60BCK-101.5, and 60BCK-111). Several of the samples with few specimens were re-run to determine if the small numbers were due to mistakes made during processing, and the results were generally the same.

Chitinozoa representing 6 genera and 17 species were found in the samples. This does not constitute a very diverse fauna. As was previously mentioned, the paucity of the Desmochitina forms is very conspicuous (if the loss of these small forms is not due to processing), since both Jenkins and Laufeld have reported large numbers of Desmochitina forms in their sections, and Jenkins (1969) has named D. minor one of the cosmopolitan elements of the Ordovician Chitinozoa. Their absence may be interpreted as some local environmental condition, but so little is known of the biology of individual forms, that no conclusions can be drawn.

The table on page 11 summarizes the affinities of my fauna with those of Jenkins, Laufeld, and Eisenack. I have identified six of the eleven cosmopolitan elements of Ordovician Chitinozoa. This was added evidence that my section was Ordovician.

I also tried to correlate my stratigraphic ranges of the forms I had in common with Laufeld's (1967) Fjäcka and Amtjärn sections. This correlated to the Middle of the Caradoc Series at Dalarna, Sweden. See Appendix I.

I tried to do the same with Jenkins' Viola-Fernvale section, but it was much harder to correlate, probably due to a misinterpretation of Cyathochitina campanulaeformis by Jenkins or me, since he did not identify any in his section at all (they are all Cyathochitina kuckersiana), while I have hundreds of specimens of this species. I may also have misnamed several specimens of Conochitina robusta (Hercochitina crickmayi?) in the upper part of the section. This is mainly due to my use of the light microscope in identifying specimens.

Due to the circumstances enumerated below, the biostratigraphy of the section will be presented, but no attempt will be made to work out any zonation.

Many problems were encountered in this study. First, the sieve I used has openings which are larger than the dimensions of the smaller Chitinozoa. By being able to pass through the sieve, these smaller forms may have been lost. I found only two specimens whose length was smaller than 100microns, and these were found in a cluster or a chain. Secondly, the sampling interval of ten feet may have prevented the discovery of the time range of some species. For example, A. multiradiata appears in only one sample in the section. A smaller sampling interval may have allowed me to establish its local stratigraphic range. Thirdly, the stratigraphic occurences of some species found by me do not conform to those established by Jenkins (1967, 1969) and Laufeld (1967). Fourthly, and most importantly, is the fact that the study of a group like the Chitinozoa through light microscopy is insufficient to allow positive identification of some forms, and renders the identification of others impossible. Only with the SEM can positive identifications be made. With continued use of the SEM, the whole classification of the group may be changed. Many new genera may be erected, and many more emended. The SEM can also 'see' inside a vesicle or its aperture (Urban,1972, and Laufeld,1974). Also, a more extensive use of photographs and plates in new publications will facilitate their identification by others interested in studying this strange and diverse group of animals.

SYSTEMATICS

The taxonomy of the group was introduced by Eisenack in 1931, and later emended by Eisenack (1955b), Taugordeau (1966), Jansonius (1964, 1967, 1970), and Collinson and Schwalb (1955).

Recently, Jansonius has divided the genus Conochitina, which many workers feel is polymorphic, into several other genera, namely Belonechitina, Hercochitina, and Kalochitina, and restricting the genus to the most slender, conical forms: the Euconochitina. He defines the new genera on the basis of spines, and their orientation on the vesicle (Conochitina forms have spines on the base only, Belonechitina forms have spines ranging haphazardly over the vesicle surface, and Hercochitina has spines arranged in longitudinal rows over the surface. The genus Kalochitina has multiple spines and a pyriform body).

This is not a new procedure; Collinson and Schwalb (1955) emended the genus Conochitina and erected the new genus Illichitina for the more bell-shaped forms (as I. campanulaeformis).

Although their zoological affinities are uncertain, for the purpose of this paper the Chitinozoa have been referred to some uncertain Class in the Phylum Protozoa.

Phylum PROTOZOA Goldfuss 1818
Class Uncertain
Order CHITINOZOA Eisenack 1931

Genus Ancyrochitina Eisenack, 1955a

Description:
A group of Chitinozoa with small vesicles, and a vesicle which is concave to pyriform. Spines are mainly on the basal edge, but they may occur on the body or the neck; the neck is well developed, and is cylindrical. The prosome is complex, and elongate.

Ancyrochitina multiradiata Eisenack, 1959
fig.

1959 Ancyrochitina multiradiata n.sp. Eisenack, p.14, pl.1, figs. 1-2.
1962c Ancyrochitina multiradiata Eisenack, p.357, pl.44, fig.17.
1967 Spinachitina multiradiata Laufeld, p.342, fig.33.
1967 Ancyrochitina multiradiata Combaz, et.al., pl. 6, fig. 220-221.

Description:
The vesicle is conical with a sharp basal edge. There is a callus and a basal scar at the aboral pole. The neck is sub-cylindrical, widening towards a fringed aperture. Ornamentation consists of hollow spines radiating from the basal edge. The operculum is thin and membranous.
length- 120microns; maximum diameter- 76 microns;
Previous known occurence: Caradoc of Europe.

cf Ancyrochitina primitiva Eisenack,1964
fig.

1964 Ancyrochitina primitiva n.sp. Eisenack, p. 323, pl. 27, fig. 1.
1967 Ancyrochitina primitiva Combaz, et.al., pl. 6, figs. 197-201.

Description:
The vesicle is conical, with a rounded basal edge, and few or no spines attached to the basal edge. The neck is sub-cylindrical, widening towards the aperture.
length- 157microns; maximum diameter- 49microns; neck diameter-41microns.
Previous known occurence: Wenlock of Europe.

Genus Conochitina Eisenack 1931

Description:
Chitinozoans with conical or elongate conical vesicles, and a rounded basal edge. Vesicles without ornamentation, or ornaments best developed near basal edge.

Conochitina cactacea Eisenack,1937
fig.

1937 Conochitina cactacea n.sp. Eisenack, p.222-223, pl. 15, figs. 14-15.
1959 Conochitina cactacea Eisenack, pp.10-11, fig. 2a,2b, pl. 1, figs. 12-13.
1962c Conochitina cactacea Eisenack, pl. 44, figs. 14-15.
1965 Conochitina cactacea Eisenack, p. 125, pl. 9, figs. 18-19.
1967 Conochitina cactacea Laufeld, p. 299, fig. 9.
1967 Conochitina cactacea Combaz, et.al., pl. 3, figs. 108-110.

Description:

The vesicle is conical or sub-conical, with a rounded basal edge, and a convex or concave base which has an invaginated aboral pole. The flexure is rounded yet distinct. The neck is cylindrical, and a shoulder is absent. Spines are simple and lambda spines, and are randomly spaced on the wall of the vesicle. The operculum thickens centrally.

length-143microns; maximum diameter-78microns; neck diameter-50microns.

Previously known occurence: Caradoc of Europe, U. Ord. of N. America.

<u>Conochitina fungiformis spinifera</u> Eisenack, 1962
fig.

1962 <u>Conochitina fungiformis spinifera</u> n.sp. Eisenack,

1967 <u>Conochitina fungiformis spinifera</u> Combaz, <u>et.al</u>., pl. 3, fig. 111.

<u>Description</u>:

The Vesicle is conical, but flares both towards the basal edge, and the aperture. The shoulder is rounded. Ornamentation is not prominent.

length-145microns; maximum diameter-54microns; neck diameter-41microns.

Previously known occurence: Middle Caradoc of Europe.

<u>Conochitina minnesotensis</u> (Stauffer, 1933)
fig.

1933 <u>Rhabdochitina</u> ? <u>minnesotensis</u> n.sp. Stauffer, p. 1209, pl. 60, fig. 39.
1939 <u>Rhabdochitina</u> ? <u>minnesotensis</u> Eisenack, p. 146, pl. B, fig. 13.
1962 <u>Conochitina minnesotensis</u> Eisenack, 1962c, pp.353-354, figs. 1-6.
1965 <u>Conochitina minnesotensis</u> Eisenack, p.126, pl. 10, figs. 7-8.
1967 <u>Conochitina minnesotensis</u> Laufeld, p. 306, fig. 13.
1967 <u>Conochitina minnesotensis</u> Combaz, <u>et.al</u>., pl.2, fig.55.

<u>Description</u>:

The vesicle wall is smooth, and the vesicle is elongate and sub-cylindrical. It may be curved. Its greatest width is near the base, and tapers towards the aperture. There is a mucro on the aboral end. The operculum is thin and membranous, with a membranous flange attached to its thickened margin.

maximum length-1550microns; maximum diameter-120microns.

Previously known occurence: Caradoc of Europe, M. Ord. of N. America.

<u>Conochitina micracantha</u> Eisenack, 1931
fig.

1931 <u>Conochitina micracantha</u> Eisenack, p. 84, pl. 1, fig. 19; holotype.

1959 Conochitina micracantha ssp. micracantha Eisenack, p. 7, pl. 1, fig. 5, pl. 3, fig. 12; neotype.
1962b Conochitina micracantha ssp. micracantha Eisenack, p. 357.
1965 Conochitina micracantha ssp. micracantha Eisenack, p. 123, pl. 9, figs.4-9.
1967 Conochitina micracantha micracantha Combaz, et.al., pl. 3, fig. 64-65, 112-113.
1969 Conochitina micracantha Jenkins, p. 10, pl. 1, figs. 17-21, text-fig. 4.

Description:

The vesicle is conical with a cylindrical neck, which flares slightly toward the aperture. The basal edge is rounded, and most of the ornamentation occurs here. It consists of simple spines. There is a prominent shoulder and very slight flexure. The aperture is fimbricate.

Included in this species are undoubtedly several other species which I could not distinguish- C. micracantha micracantha Eisenack, and C. suecica Laufeld.

length-180-333 microns; maximum diameter-72-93microns; neck diameter-40-60microns.
Previously known occurence: Llandeilo-Caradoc of Europe, and M. Mid. Ord.-M. Upper Ord. of North America.

Conochitina robusta Eisenack, 1959
fig.

1959 Conochitina micracanthassp. robusta n.sp. Eisenack, pp. 9-10, pl. 1, fig. 6, pl.3, fig. 4-5.
1965 Belonechitina robusta Jansonius, pp. 906-907, pl. 2, figs. 24-25.
1967 Conochitina robusta Laufeld, p. 307, fig.14.
1967 Conochitina micracantha robusta Combaz, et.al., pl. 3, figs. 69-71.
1969 Conochitina robusta Jenkins, p. 15, pl.3, figs3-5.

Description:

Vesicle is elongate and conical or club-shaped, with the greatest width just oralward of the basal edge. The neck is cylindrical, or widens slightly towards the aperture. Flexure is absent or rounded, and there is no shoulder. Ornamentation is strong, and consists of simple and lambda spines with multiramose roots, best developed on aboral part of vesicle. There is a disc-like operculum with a membranous flange.

length-240-430microns; maximum diameter-71-100microns; neck diameter-50-75microns.
Previously known occurence: U. Caradoc of Europe

Conochitina tuberculata Eisenack, 1962
fig.

1962a Conochitina tuberculata Eisenack, p. 308, pl. 15, fig. 2.

1962b <u>Conochitina tuberculata</u> Eisenack, p. 357
1965 <u>Conochitina tuberculata</u> Eisenack, p. 122, pl. 11, fig. 4-5.
1967 <u>Conochitina tuberculata</u> Combaz, <u>et</u>.<u>al</u>., pl.2, fig. 41.

<u>Description</u>:
The vesicle is long and conical, with a flaring aperture. The basal edge is rounded; there is no prominent flexure, shoulder, or ornamentation. The vesicle wall is smooth.
lenght- 630microns; maximum diameter- 86microns.
Previously known occurence: Llanvirn-Llandeilo of Europe.

Genus <u>Cyathochitina</u> Eisenack, 1955

<u>Description</u>:
The vesicle is conical to bell-shaped, with a well developed cylindrical neck. The shoulder is absent, while the flexure is pronounced. The vesicle wall is generally smooth. The basal edge is sharp, and provided with a membranous flange. There is often a strong basal scar.
The genus has been emended by Jansonius (1964), out of which came <u>Tanuchitina</u>.

<u>Cyathochitina campanulaeformis</u> (Eisenack, 1931)
fig.

1931 <u>Conochitina campanulaeformis</u> n.sp. Eisenack, pp. 86-87, pl. 2, figs. 1-2, pl. 4, figs. 1, 11-13.
1939 <u>Conochitina campanulaeformis</u> Eisenack, p. 137, pl.B, figs. 1-3.
1948 <u>Conochitina campanulaeformis</u> Eisenack, p. 112, figs. 1, 7-9.
1955 <u>Illichitina campanulaeformis</u> n. gen. Collinson and Schwalb, p. 29.
1955 <u>Cyathochitina campanulaeformis</u> Eisenack, p. 313.
1962a <u>Cyathochitina campanulaeformis</u> Eisenack, p. 297- 298, fig. 3, pl. 14, figs. 5-7.
1963 <u>Cyathochitina campanulaeformis</u> Kozlowski, pp. 435-439, figs. 8-10.
1967 <u>Cyathochitina campanulaeformis</u> Laufeld, p. 313, fig. 17.
1967 <u>Cyathochitna campanuleformis</u> Jenkins, pp. 456-457, pl. 71, figs. 8-11.
1967 <u>Cyathochitina campanulaeformis</u> Combaz, <u>et</u>.<u>al</u>., pl.8, fig. 317.
1968 <u>Cyathochitina campanulaeformis</u> Eisenack, p. 168, pl. 24, fig. 1-3; pl. 29, fig 18-19; pl. 31, fig 1-2; pl. 32, fig. 5.

<u>Description</u>:
The vesicke is bell-shaped, with a sub-cylindrical to cylindrical neck. The wall has a granular surface. The base is composed of a thickened polar part with a central perforation, sealed by a thin membrane. There is a membranous skirt attached

to the outer edge of the operculum.
length- 200-432microns; maximum diameter- 90-150 microns.
Previously known occurence: U. Ord.-M. Sil. of Africa, M. Ord-L. Sil. of No. America, and Llanvirn-M. Ludlow of Europe.

<u>Cyathochitina kuckersiana</u> (Eisenack, 1934)
fig.

1934 <u>Conochitina kuckersiana</u> n.sp. Eisenack, pp. 62-63, figs. 30-31, pl. 4, fig. 14.
1955 <u>Cyathochitina kuckersiana</u> Eisenack, p. 313.
1962a <u>Cyathochitina kuckersiana</u> Eisenack, pp. 298-300, figs. 4-5; pl.14, figs. 8-9.
1967 <u>Cyathochitina kuckersiana</u> Laufeld, pp. 315-316, fig. 18.
1967 <u>Cyathochitina kuckersiana</u> Jenkins, p. 458, pl 72, figs. 3-9; pl. 73, figs. 1.
1967 <u>Cyathochitina kuckersiana</u> Combaz, <u>et</u>. <u>al</u>., pl. 8, figs. 318-321.
1968 <u>Cyathochitina kuckersiana</u> Eisenack, pl. 29, fig, 20.

<u>Description</u>:
The vesicle is shorter, with a sub-cylindrical neck which composes over one-half of the length. The flexure is weak, and the shoulder is absent. The aperture is straight. There is a thickened basal edge with a translucent and undulating flange protruding from it. There is a basal scar which has a concentric structure, and there is a skirt attached to the operculum.
length- 310-410microns; maximum diameter- 150-205microns.
Previously known occurence: U. Middle Ord. of No. America, M. Sil. of Africa, and Llandeilo-Caradoc of Europe.

Genus <u>Desmochitina</u> Eisenack, 1931

<u>Description</u>:
Vase and jug-shaped Chitinozoa with a widened collar orally attached at either a sharp or a gentle angle to the body. The operculum is external. Ornamentation is slight ans delicate.

<u>Desmochitina minor</u>? Eisenack, 1931
fig.
1931 <u>Desmochitina?minor</u> Eisenack, p. 93, pl. 3, fig.9-11; holo.
1931 <u>Desmochitina? erinacea</u> Eisenack, p. 93, pl. 3, fig. 13.
1931 <u>Desmochitina? cocca</u> Eisenack, p. 94, pl. 3, fig. 14-15.
1931 <u>Desmochitina amphorea</u> Eisenack, p. 93, pl. 3, fig.5,12.
1932 <u>Desmochitina amphorea</u> Eisenack, p. 267, pl. 12, fig.6.
1939 <u>Desmochitina minor</u> Eisenack, p. 142, pl. A, figs. 2-5.
1948 <u>Desmochitina minor</u> Eisenack, p. 115, text-figs. 14,15.
1958b <u>Desmochitina minor</u> Eisenack, p. 397, pl. 2, fig.29; neot.
1962a <u>Desmochitina minor</u> Eisenack, p. 303, pl. 16, figs. 1-3, neotype, 4-10.

1965 *Desmochitina minor* f. *typica* Eisenack, p. 130, pl. 10, figs. 16-17.
1967 *Desmochitina minor* Laufeld, p. 328, fig. 25.
1967 *Desmochitina minor* Jenkins, pp. 459-460, pl. 71, figs. 12-18, pl. 72, figs. 1-2.
1967 *Desmochitina minor* Combaz, *et.al*, pl. 7, fig. 240.
1968 *Desmochitina minor* Eisenack, p. 180.
1969 *Desmochitina minor* Jenkins, p. 20, figs. 1-20.

Description:
The vesicle is ellipsoidal with its greatest width near the longitudinal axis. It has a slightly flattened base. There is a conical collar attached at an acute angle to the oral part of the vesicle. The vesicle is covered by delicate spines. These Chitinozoa may be found in clusters or chains
length- 78-86microns; maximum diameter-61-71microns.
Previously known occurence: M. Ord. of No. America, and Llanvirn -Caradoc of Europe.

Desmochitina minor f. *elongata* Eisenack, 1958
fig.

1958 *Desmochitina minor* f. *elongata* Eisenack, p.398, pl. 2, fig. 31-32.
1962 *Desmochitina minor* f. *elongata* Eisenack, p. 305, pl. 16, figs. 19-20.
1962 *Desmochitina minor* f. *elongata* Eisenack, p. 357.
1967 *Desmochitina minor elongata* Combaz, *et.al*., pl. 7, fig. 251-252.
1968 *Desmochitina minor* f. *elongata* Eisenack, p. 180. pl. 24, figs. 23-25.

Description:
The same description as for *D. minor*, except that these vesicles are slightly more elongate, and more slender.
length-88-118microns; maximum diameter- 59-79microns.
Previously known occurence: Llanvirn-Llandeilo of Europe.

Genus *Hercochitina* Jansonius, 1964

Description:
Vesicles with a conical body and cylindrical neck. There is a rounded basal edge. The body is strongly ornamented, with pi and lambda spines, some resembling vertical ribs, and attached in longitudinal ridges to the vesicle wall.
This genus has been emended from *Conochitina* (Eisenack,1931).

Hercochitina crickmayi Jansonius, 1964
fig.

1964 *Hercochitina crickmayi* Jansonius, p. 908, pl. 1, figs. 9 (holotype), 10-11.
1967 *Hercochitina crickmayi* Combaz, *et.al*., pl. 10, fig. 417.

1969 <u>Hercochitina crickmayi</u> Jenkins, p. 26-28, pl.8, figs. 1-11, text-figs. 8, 10.

<u>Description</u>:

The vesicle is conical, and is highly ornamented with spines, of pi and lambda type. The bsal edge ranges from very narrow to broad and rounded. The neck is short. There is a single layer cuticle.

Jenkins (1969) recognizes two subspecies, between which I have made no distinction.

length- 330-380microns; maximum diameter- 100-118microns; neck diameter- 60-89microns.
Previously known occurence: U. Ord. of No. America.

Genus <u>Rhabdochitina</u> Eisenack, 1931

<u>Description</u>:

These are large, elongate, cylindrical vesicles, with a smooth surface. Some have a mucro on the aboral end. Most flare somewhat towards the aperture.

<u>Rhabdochitina gracilis</u> Eisenack, 1962
fig.

1962 <u>Rhabdochitina gracilis</u> Eisenack, p. 307, pl. 14, figs. 24-25.
1962 <u>Rhabdochitina gracilis</u> Eisenack, p. 357.
1967 <u>Rhabdochitina gracilis</u> Combaz, <u>et</u>.<u>al</u>., pl.4, figs. 124-125.

<u>Description</u>:

These vesicles are long, narrow, and cylindrical. There is no prominent ornamentation. The basal edge is rounded. Some forms have a mucro.

length- 840microns; maximum diameter- 60-80microns.
Previously known occurence: M. Llanvirn to M. Caradoc of Europe.

<u>Rhabdochitina hedlundi</u> Taugordeau, 1965
fig.

1965 <u>Rhabdochitina hedlundi</u> Taugordeau
1967 <u>Rhabdochitina hedlundi</u> Combaz, <u>et</u>.<u>al</u>., pl. 4, fig. 128.

<u>Description</u>:

The vesicle is conical, and flares towards the aperture to a fimbricate lip. The wall is smooth. In most cases the basal edge is rounded, but distinct. Some forms have a mucro at the aboral end.

length- 570microns; maximum diameter- 65-95microns.
Previously known occurence: U. Ord. of No. America.

Rhabdochitina magna Eisenack, 1931
fig.

1931 Rhabdochitina magna Eisenack, p. 90, pl. 3, fig. 16-18 holotype.
1939 Rhabdochitina magna Eisenack, p. 145, pl. B, fig. 9.
1960 Rhabdochitina magna Taugordeau and Jekhowsky, p. 1230, pl. 9, fig. 132.
1961 Rhabdochitina magna Benoit and Taugordeau, p. 1411, pl. 5, fig. 54.
1962a Rhabdochitina magna Eisenack, p. 292, pl. 4, fig. 1.
1967 Rhabdochitina magna Combaz, et. al., pl. 4, fig. 119-121.
1967 Rhabdochitina magna Jenkins, pp. 466-467, pl. 74, fig. 6,9-10, 12.

Description:
This species is characterized by a long, cylindrical vesicle, which is fairly wide, and has no prominent ornamentation. The basal edge is rounded, with a flattened base.
length- 610-1300microns; maximum diameter- 100-130microns.
Previously known occurence: U. Ord. of No. America.

Rhabdochitina usitata Jenkins, 1967
fig.

1967 Rhabdochitina usitata n.sp. Jenkins, p. 468, pl. 74, figs. 13-15, 20; pl. 75, fig. 1.
1969 Rhabdochitina usitata Jenkins, p. 29, pl. 9, figs. 10-12.

Description:
The vesicle is stout, cylindrical , or weakly conical, with a hemispherical base. The wall is smooth, and the aperture is straight.
length- 440 microns; maximum diameter- 126microns.
Previously known occurence: Llanvirn of Europe.

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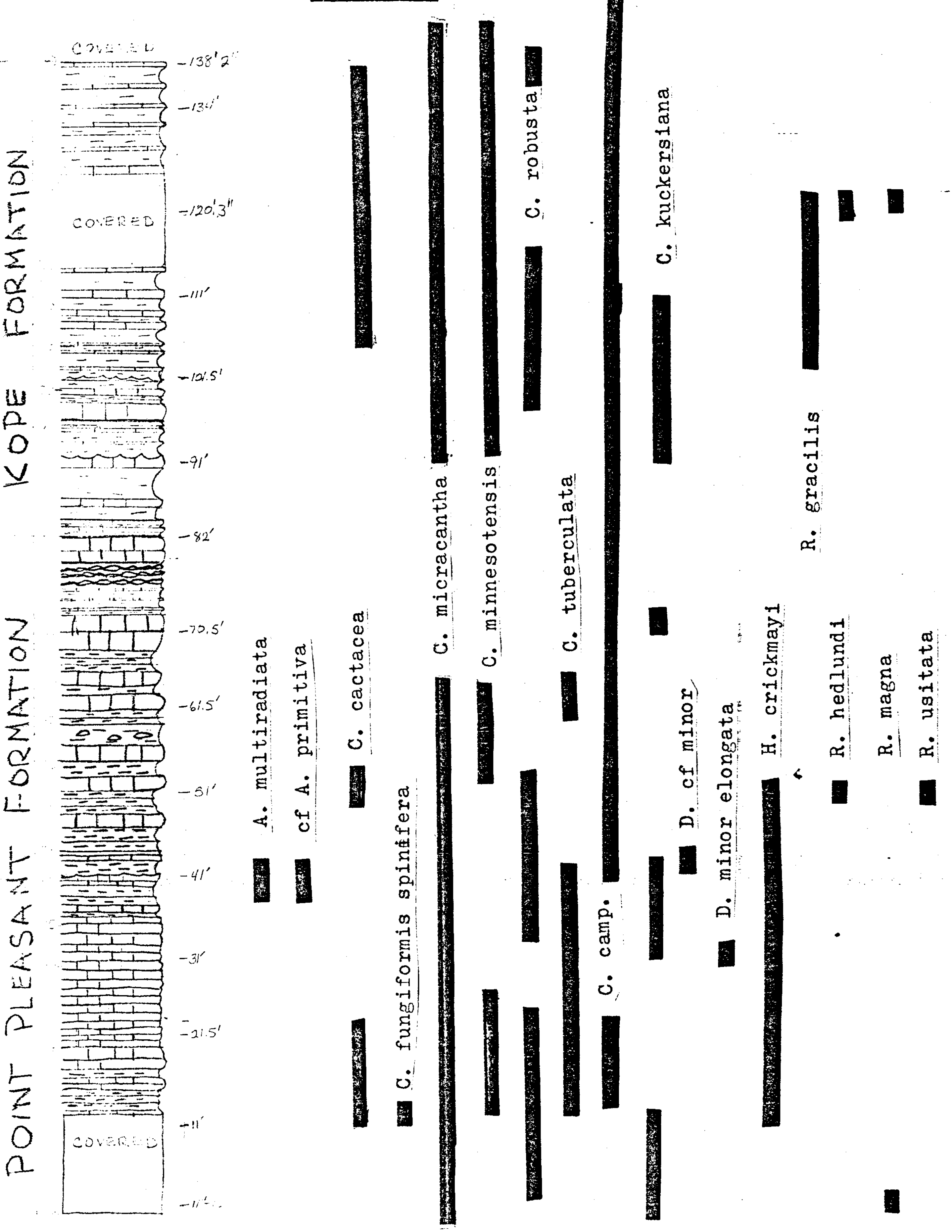
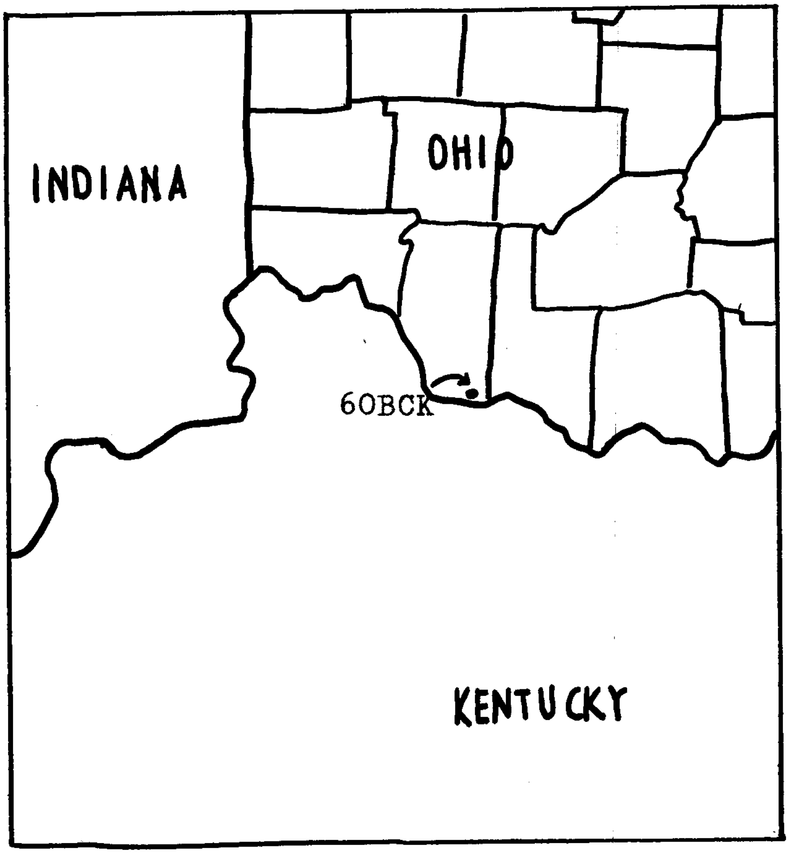
APPENDIX

APPENDIX I



Ranges of the identified species of the Bear Creek section



Location of the Bear Creek Quarry section; from: 'Conodonts from the Lexington Limestone (Middle Ordovician) of Kentucky and its Lateral equivalents in Ohio and Indiana' by Bergström and Sweet, 1966.

APPENDIX II

Lithology of the samples

60BCK- 138'2". Limestone, dark grey; very fossiliferous; fine-grained, with some recrystalized calcite.

134. Limestone, medium grey; very fossiliferous; medium grained, has some clay.

120'3". Limestone, dark grey; fossiliferous; fine-grained; some recrystallized calcite, some pyrite, much clay.

111. Shale, light brown; very soft; thinly bedded, with calcite cement.

101.5. Shale, light brown; very soft; thinly bedded, with calcite cement.

91. Limestone, medium grey; fossiliferous; fine-grained, with some recrystallized calcite.

82. Limestone, dark grey; medium grained, with re-crystallized calcite.

70.5. Limestone, dark grey; fossiliferous; medium-grained, with recrystallized calcite.

61.5. Limestone, dark grey; fossiliferous; very fine-grained, with some recrystallized calcite.

51. Limestone, medium grey; fine-grained.

41. Limestone, dark grey; fossiliferous; medium-grained, with recrystallized calcite, and some clay.

31. Limestone, medium grey; fossiliferous; fine-grained, with some recrystallized calcite; clayey.

21.5. Limestone, light grey; fossiliferous; very fine-grained, with some recrystallized calcite.

11. Limestone, light grey; fine-grained, and silty.

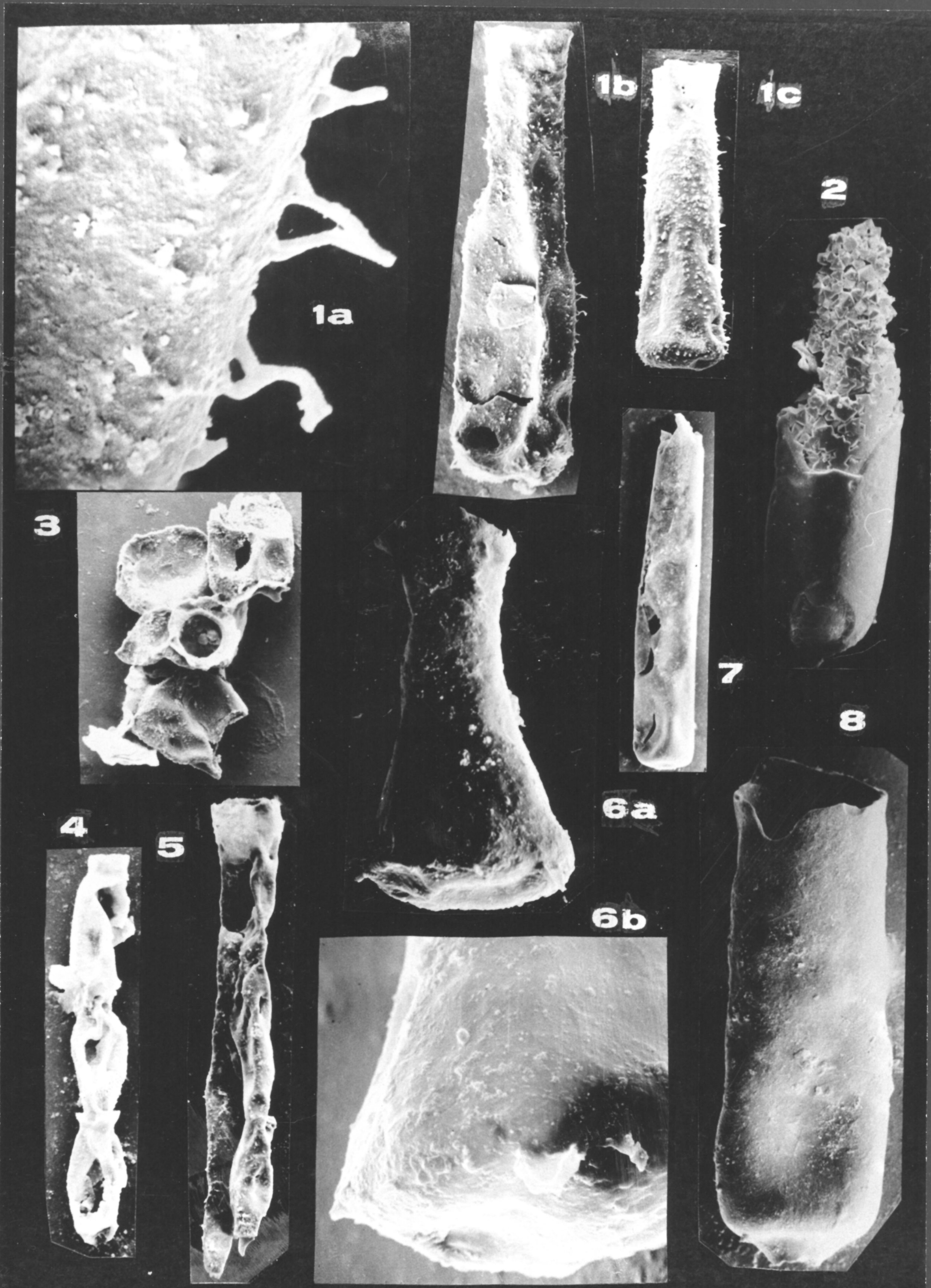
11"-12". Limestone, medium grey; fossiliferous; fine-grained, with some clay.

The last figure of the sample number denotes the feet above the base of the section (the quarry floor).

PLATES

PLATE ONE

fig. 1a. *Conochitina robusta* Eisenack; 340X.
fig. 1b. *C. robusta*; 3400X. detail of 1a.
fig. 1c. *C. robusta*; 255X.
fig. 2. *Rhabdochitina usitata* Jenkins; 125X.
crystals are pyrite.
fig. 3. *Desmochitina* cf. *minor* Eisenack; 340X;
cluster of four vesicles.
fig. 4. *Desmochitina minor elongata* Eisenack; 250X.
chain of three vesicles.
fig. 5. *Rhabdochitina magna*? Eisenack; 140X.
fig. 6a. *Ancyrochitina* cf *primitiva* Eisenack; 625X.
fig. 6b. *A.* cf. *primitiva*; 1300X. detail of base.
fig. 7. *Conochitina minnesotensis* Stauffer; 125X.
fig. 8. *C. minnesotensis*; 310X. incomplete specimen,
but notice mucro on base.


1a
1b
1c
2
3
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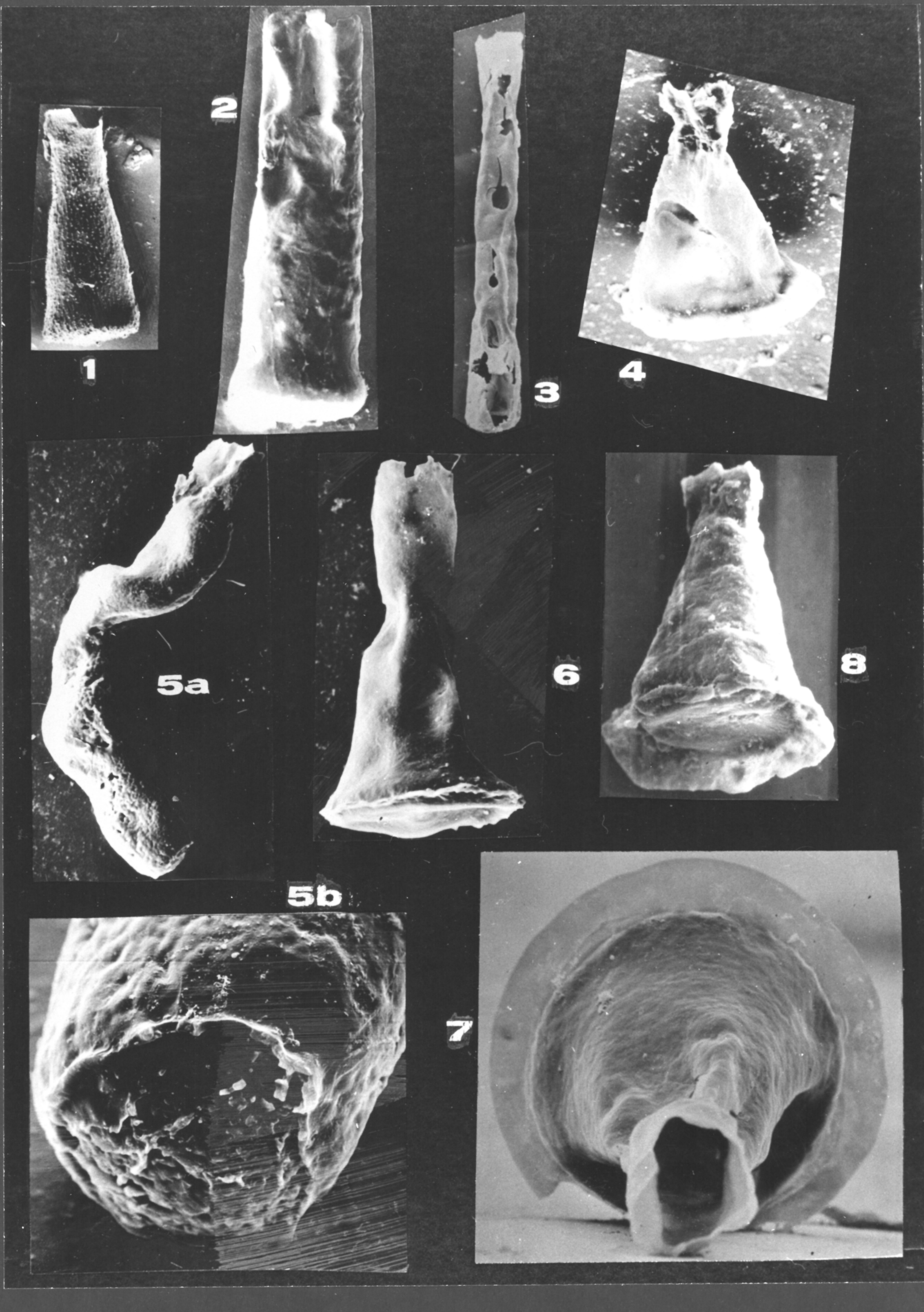
6a
6b
7
8

PLATE TWO

fig. 1. <u>Hercochitina crickmayi</u> Jansonius; 300X.
fig. 2. <u>H. crickmayi</u>; 350X.
fig. 3. <u>Conochitina tuberculata</u> Eisenack; 140X.
fig. 4. <u>Cyathochitina kuckersiana</u> Eisenack; 560X.
fig. 5a. <u>Rhabdochitina hedlundi?</u> Taugordeau; 125X.
fig. 5b. <u>R. hedlundi?</u> 685X. detail of base.
fig. 6. <u>Cyathochitina campanulaeformis</u> Eisenack; 420X.
fig. 7. <u>C. campanulaeformis</u>; 520X; oral view.
fig. 8. <u>C. campanulaeformis</u>; 450X.


1
2
3
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5a
5b
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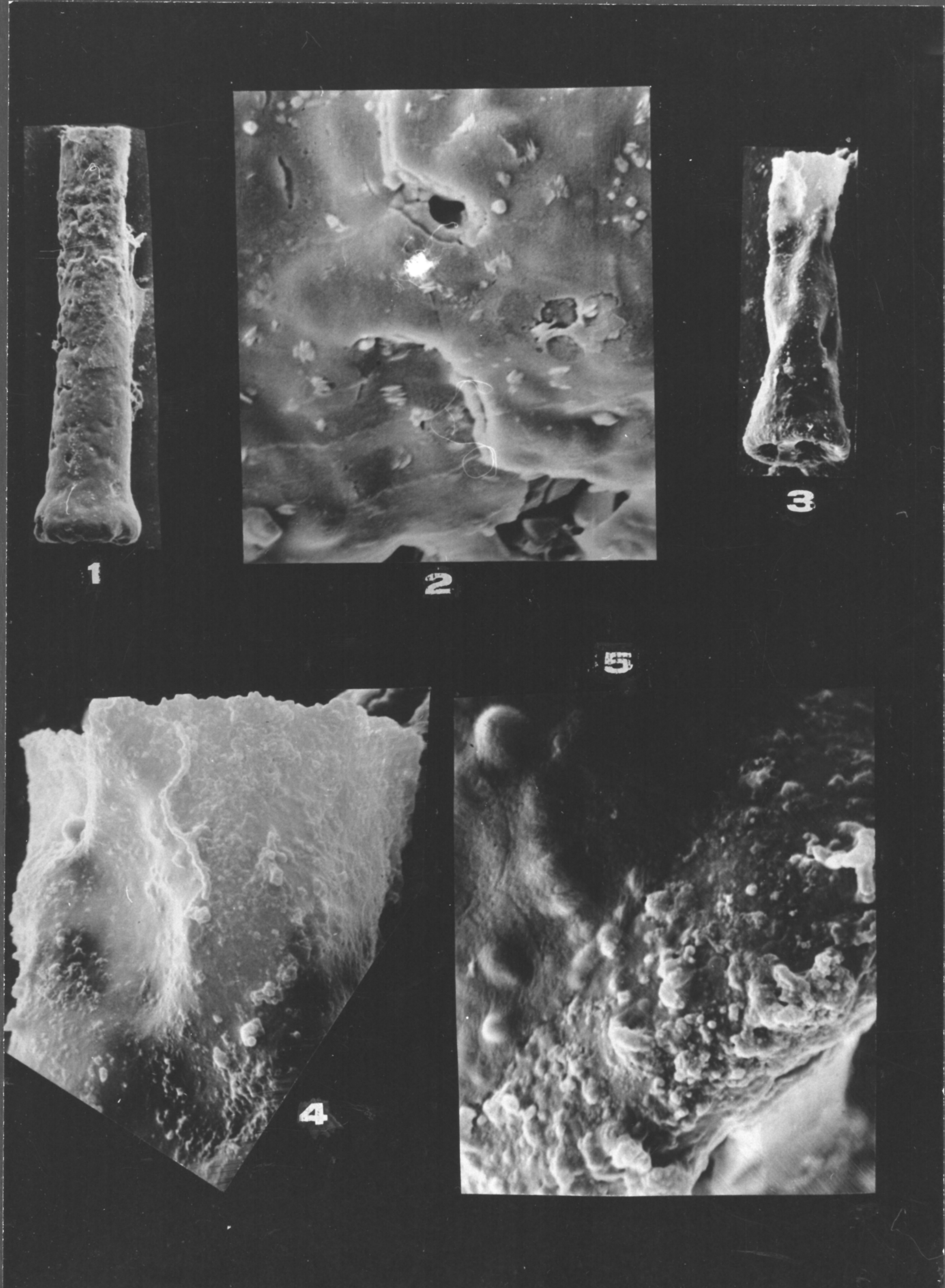
7
8

PLATE THREE

All figures are of *Conochitina micracantha*

fig. 1. 370X.
fig. 2. 2650X; detail of 1. Notice the granules.
fig. 3. 300X.
fig. 4. 1500X; oral end of vesicle of 3.
fig. 5. 1500X; basal edge of vesicle of 3.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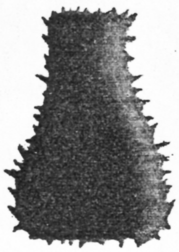
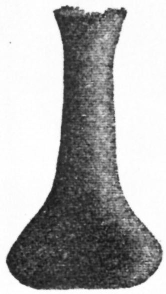
FORMS WHOSE PHOTOGRAPHS COULD NOT BE TAKEN



Conochitina cactacea

130 microns



Conochitina fungiformis spinifera

140 microns

Ancyrochitina multiradiata

150 microns